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Compiled by
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Lockheed
MISSILES & SPACE COMPANY
A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION
SUNNYVALE, CALIFORNIA

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ABSTRACT

The references cited were selected primarily from the literature of 1958–1962. It is significant to note that 65 percent of the references are to journals or books published by the Soviet Bloc. Pertinent papers on the influence of vibrations during the solidification of castings are included.

Abstracts are arranged in alphabetical order by author.

TABLE OF CONTENTS

1. Alov, A. A. and V. S. Vinogradov
The effect of vibration of the electrode on the process of arc welding and the properties of the welds. SVAROCHNOE PROIZVODSTVO 31(9):19–22, Sep 1958. (In Russian) (Available in English as Brutcher Translation 4670)

Low carbon steels were welded with an electrode vibrating at amplitudes and frequencies up to 60 cps. The arc was found to be more stable, burn-through was decreased and the structure of the weld metal was improved. The weld metal was less porous and cracks were reduced.

2. Altman, M. B.
Structure and properties of aluminum and aluminum alloys with ultrasonic treatment. IZVESTIYA AKAD. NAUK SSSR, OTN, METALL. i TOPLIVO 3:88–91, May–Jun 1959. (In Russian) (Available in English as Brutcher Translation No. 4776)

Discusses methods for introducing vibrations into the melt. Degassing, grain refinement and mechanical properties were improved.

3. Altman, M. B., et al.
Degassing of aluminum alloys by ultrasound. IZVESTIYA AKAD. NAUK SSR, OTN 9:25–30, Sep 1958. (In Russian) (Available in English as Brutcher Translation No. 4417)

Vibrations at 20,Kcps were used. Methods for determining the degree of degassing are included.

4. Benua, F. F., I. V. Vologidn and A. I. Katler
Study of vibration effect on crystallization and structure of metal welded by flux-bath method. SVAROCHNOE PROIZVODSTVO p.1–5, May 1958. (In Russian)

Effects of vibrations from 1500 to 2600 cpm on molten weld metal during its crystallization were studied. Large dendrites were broken up into smaller ones and grain size was reduced. The structure and ductility were improved.

5. Berger, M. J. and W. Rostoker
Effects of vibration during solidification of castings. FOUNDRY 81(7):100–105, 260–265, Jul 1953.

The use of sonic and ultrasonic generators and electromagnetic and pneumatic vibrators is discussed. As-cast grain sizes are refined by using vibrations.

6. Brown, D. C., et al.
Effect of electromagnetic stirring and mechanical vibration on arc welds. WELDING JOURNAL 41:sup 241–250, Jun 1962

Grain refinement is produced in commercially pure 6% Al-4%V titanium alloys and type 304 stainless steel and an aged 13% V-11% Cr-3% Al titanium alloy showed improved strength and ductility.

7. Carnahan, D.R., J.H. Kelley and L.M. Bianch
Vacuum-arc ingot grain refinement. In VACUUM METALLURGY CONFERENCE 1959, TRANSACTIONS. N.Y., N.Y. University Press, 1960. p.49–57.

Grain refinement in vacuum-arc furnaces is achieved by magnetic stirring, a controlled power input and ultrasonic vibration. Ferritic- and austenitic-base materials have been produced with a fine as-cast grain structure.

8. Crossley, F. A., et al.
Viscous shear as an agent for grain refinement in cast metal. AIME TRANS. 221:419–420, 1961.

Magnetic stirring was applied to the consummable arc melting of aluminum and nickel to show that grain refinement would occur if sufficient stirring force was applied. The polarity of the current through the stirring coil was alternately reversed to achieve grain refinement in aluminum.

9. Doudko, D. A. and I. N. Roublevskij
The influence of electrode vibration on the droplet transfer of electrode metal in the electroslag process. AUTOMATIC WELDING 1:28–34, Jan 1959. (Translated from AVTOMATICHESKAYA SVARKA No. 1, p.25–29, Jan 1959)

A rig is described which is used to study changes in metal transfer influenced by a vibrating electrode. It was found that droplet size may be increased or reduced by the vibrations. The effect of the vibrations on the resulting grain structures are discussed.

10. Erdmann, F., W. Schroder and J. Schubert
The effect of magnetic fields in arc welding. WERKSTATT UND BETRIEB 94:183–185, Aug 1961. (In German)

The effects of an axial magnetic field on voltage, current and temperature of the welding process and on penetration and fusion in the weld zone are discussed. The influence of the magnetic field of the arc on the transition of drops during the welding of steel in an inert atmosphere is also discussed.

11. Erokhin, A. A.
The basic stages in arc welding and their metallurgical characteristics. IZVEST. AKAD. NAUK SSSR MET.i TOPL. 2:77–82, 1961. (In Russian)

The main welding stage occurs when the metal is in droplet form in the pool and on the electrode. The heating of the coating when coated electrodes are used is considered a separate stage preceding droplet formation. When a permanent electrode is used the reactions in the pool change considerably, but not as much as in the droplets in which the reaction proceeds almost to completion because of better contact conditions.

12. Erokhin, A. A. and L. L. Silin
Methods of introducing ultrasonic oscillations into weld pools. WELDING PRODUCTION 5:8–13, May 1960. (Translated from SVAROCHNOE PROIZVODSTVO p.4–7, May 1960) (Also in ENGINEER'S DIGEST 21(7):81–82, Jul 1960)

Weld pool agitation was achieved by transmitting ultrasonic vibrations through the filler wire. Other methods for agitating the pool are discussed.

13. Erokhin, A. A., G.F. Balandine and V.D. Kodolov
Effects of ultrasonic vibrations on weld crystallization in electro-slag welding. AUTOMATIC WELDING 1:18–24, Jan 1960. (Translated from AVTOMATICHESKAYA SVARKA 1:15–20, Jan 1960)

Less cracking and a reduction in grain size occurs when the weld pool is vibrated.

14. Erokhin, A.A., et al.
The influence of ultrasonic vibrations on the character of the crystallization of weld metal.
IZVEST. AKAD. NAUK SSSR 1:140–142, 1958.
(In Russian)

A finer grain structure in a weld resulted when a magnetostriction device was used in conjunction with argonarc welding apparatus during the welding of high temperature austenitic steel.

15. Freedman, A. H. and J. F. Wallace
Vibrating strength into metals. MOD. CASTINGS 31(4):64–74, 1957.

Aluminum and copper alloys were vibrated at 60 or 20,000 cps. Grain size was improved as was alloy strength when alloys solidified as single phase solid solutions. Vibrations at higher frequencies were more effective.

16. Garlick, R. G. and J. F. Wallace
Grain-refinement of solidifying metals by vibration. AMER. FOUND. SOC. TRANS. 67:366–374, 1959. (Also in MODERN CASTINGS 1959, 35(6):86–94)

Vibration effects upon pure metals, solid solutions and entectics were studied under controlled solidifying conditions. Grain refinement occurred in every case and was greater in those metals which contract more during solidification. Results concur with the theory that vibration produces grain refinement by increasing the nucleation rate.

17. Guevorkian, V. G. and A. G. Teplov
Technology of part surfacing by arc welding with a vibrating head. MACHINOSTROITEL' p.11–14, Jan 1960; p.39, Mar 1960. (In Russian)

Thin layers of weld metal are built up while the part being welded shows negligible heating. Possible defects which may occur and means for their prevention are discussed.

18. Hrbal, Pavel
Effect of a vibrating electrode on weld porosity. ZVARANIE 7:169–171, Jun 1958. (In Czechoslovakian)

Porosity did not decrease when a vibrating holder (invariable frequency) was used during root welding in difficult positions.

19. Kodolov, V. D.
Introduction of elastic ultrasonic waves into the welding bath. AUTOMATIC WELDING 4:31–35, Apr 1961. (Translated from AVTOMATICHESKAYA SVARKA 4:35–39, Apr 1961)

Parameters governing design and use of equipment for applications in the electroslag welding and arc welding of thick plates of austenitic steel. Effect of ultrasonic waves on resistance to hot cracks and intercrystalline corrosion.

20. Kushta, G. P. and B. G. Strongin
The submicroscopic structure of metals and alloys which have crystallized under vibration. PHYSICS OF METALS AND METALLOGRAPHY 5(1):160–161, 1957. (In English) [Translated from the Russian FIZIKA METALLOV I METALLOVDENIE 5(1):187–188]

When a metal is vibrated during solidification, grain size falls as the frequency or amplitude of vibration increases. Microhardness was also shown to increase leading to the supposition that vibration also refines the mosaic structure.

21. Lane, D., J. Cunningham and W. A. Tiller
The application of ultrasonic energy to ingot solidification part I. AIME TRANSACTIONS 218(6):985–990, Dec 1960.

Lane, D. and W. A. Tiller
The application of ultrasonic energy to ingot solidification part II. AIME TRANSACTIONS 218(6):991–994, Dec 1960.

Effects of vibrations on solidification have been considered experimentally and theoretically. Results support the contention that ultrasonic vibrations increase the nucleation frequency in the layer of liquid adjacent the freezing interface.

22. Mann, K. E. and E. Riepert
Grain-refinement of continuous castings by stirring the pool. METALL 10(5/6):195–199, 1956. (In German)

A propellor rotated in the metal during solidification caused an improvement in the grain structure, a reduction of cold shuts and an increased tendency to crack in Al-Zn-Mg billets. Next, vertical currents were induced in the pool without disruption of the metal/air interface and thus reduced the formation of oxide inclusions. In certain alloys, the cracking tendency was reduced and grain refinement was improved but cold shuts were increased.

23. Nagy, M. J., Jr. and D. M. Kelman
Application of ultrasonic vibrations during solidification of vacuum-arc melted ingots.
METALS ENGINEERING QUARTERLY
1:72–82, Nov 1961.

Describes how ultrasonic vibrations could refine ingot structure at the freezing interface of vacuum-arc melted ingots. When the technique was applied to the consumable-electrode melting process, suppressed columnar grains yielded an ingot structure consisting mostly of equiaxed grains. Several materials were used in the study.

24. Novikov, I.I., G.A. Korol'kov and V.S. Zolotorevskii
Mechanism of grain refinement during recrystallization controlled by low frequency vibrations.
IZVEST. VUZ - CHERNAYA METALLURGIYA
5:130–134, May 1960. (In Russian)

The fragmentation hypothesis does not account for grain refinement caused by vibration at sonic frequencies.

25. Novikov, I.I., et al.
Grain-refinement by vibration during the solidification of (aluminum) melts.
LITEINOE PROIZVODSTVO 9(2):42, 1959.
(In Russian) (Also available in English as Brutcher Translation No. 4563)

A vibrator moved steadily upward at a constant distance from the solidification front caused grain refinement. When the vibration was stopped before the top of the ingot was reached, there was an abrupt change to a coarse structure near the top. The use of vibrations during semi-continuous casting might be successful when other grain refinement methods fail.

26. Novikov, I.I., et al.
Use of vibrations during solidification (of alloys) to eliminate hot tears. 1959.
(Order from Henry Brutcher, Altadena, Cal., Translation no. HB-4753, $3.75, Translated from LITEYNOYE PROIZVODSTVO 1:7–8, 1958)

Investigation into effect of vibrations on hot tearing of alloys in process of solidifying. Experimental setup. Influence of vibration frequency on development of hot tears: tears healed at subcritical vs. critical vibration frequencies. Results of microexamination of healed tears. Benefits derived from vibrating: fewer hot tears; wider use (e.g. for high-strength alloys) of permanent mold casting; better filling of mold contours; better degassing of melt. How to determine the critical frequency and the best amplitude of vibrations. Ways in which surface roughness of vibrated castings can be overcome in many instances. (Henry Brutcher abstract)

27. Novikov, I. I., et al.
Mechanism of grain refinement by low-frequency vibrations during crystallization (of metals). Aug. 1960. (Order from Henry Brutcher, Altadena, Cal., Translation no. HB-4900, $3.75, Translated from IZV[ESTIYA] V[YSSHIKH] U[CHEBNYKH] Z[AVEDENIY]. CHERN[AYA] MET[ALLURGIYA] 5:130–134, 1960.

28. Pogodin-Alekseyev, G.I. and V.V. Zaboleyev-Zotov
New process for production of alloys.
NOVYY SPOSOB PRIGOTOVLENIYA METALLICHESKIKH SPLAVOV Feb 1960.
(Order from Henry Brutcher, Altadena, Cal., Translation no. HB-4779, $3.50, Translation from LITEYNOYE PROIZVODSTVO, 7:25–26, 1958)

Report on a new method for producing alloys by which the main component is added in the solid state either in dispersed form or in that of a rod, to a molten mixture of the remaining part of the alloy, uniform distribution of the principal component being ensured by sonic or ultrasonic vibrations. Experimental arrangement and procedure. Preparation of an alloy of lead with tungsten carbide; structure. Importance of a sufficient input of (ultra) sonic energy. Applications and general advantages of method over casting and sintering; specific merits when compared with powder metallurgy. (Henry Brutcher)

28a. Pulsonic welding: The development of a new joining technique. WELDING 30(6):235–239, 1962.

Vibrations are applied to the weld pool perpendicular to the interface between the electrode and the workpiece. A prototype machine was developed.

29. Puszet, B.
Repair of worn surfaces by welding with a vibrating electrode. La MACHINE-OUTIL FRANCAISE 25(150):109, 111 and 113, Jan 1960. (In French)

Shafts are repaired by a building-up process. Details are given of an operation cycle in which the electrode vibrates vertically, and is periodically brought into contact with the part to be built-up as it rotates.

30. Richards, R. S. and W. Rostoker
The influence of vibration on solidification of an aluminum alloy. ASM TRANSACTIONS 48:884, 1956.

31. Russo, V. L.
INVESTIGATION OF THE EFFECT OF ELASTIC VIBRATIONS OF VARYING FREQUENCIES ON THE CRYSTALLIZATION OF THE WELD POOL. In WELDING: COLLECTION OF ARTICLES (SELECTED PARTS). Aerospace Technical Intelligence Center, Wright-Patterson AFB, Ohio. Translation No. MCL-496/1, 21 Mar 1961, 149p. ASTIA AD-258 812 (Translated from Svarka-Sbornik Statey, Leningrad, p.3–15)

32. Russo, V. L. and P. N. Efimov
The influence of low-frequency vibration on the solidification of the molten metal and the properties of the weld metal. SVAROCHNOE PROIZVODSTVO 5(11):10–12, 1958. (In Russian)

Experiments were carried out on steel and aluminum alloy sheet at frequencies of 25, 46, and 55 cps and amplitudes between 0.01 and 2.3 mm. Low frequency vibrations caused pressure impulses to be set up during solidification, at a certain value of which the ends of the growing dendrites are broken off to form additional crystalline nuclei, causing refinement and disorientation of the primary structure. In the materials investigated, an increase in frequency led to a reduction of primary grain-size and an increase in impact strength. Welding of aluminum alloys in this range can be carried out under normal welding parameters. Greater grain-refinement might be obtained by vibrating with ultrasonic frequencies.

33. Schmid, G. and A. Rodd
The importance of frequency and intensity of vibration on grain refinement. ZEITSCHRIFT fuer ELEKTROCHEMIE 45:769, 1939.

34. Serkovsky, V. A.
Effect of vibrations (during casting and solidification) on the properties of a metal. LITEINOE PROIZVODSTVO 5:19–21, 1958. (In Russian)

Aluminum alloys were tested to confirm the effects of vibrational treatment on metals during casting as predicted by theory. Harmful effects of gases were reduced and the alloy was improved, and there was an improved flow to thin sections, improved grain-refinement, a breaking-up of columnar structures, and an improved pressure tightness. Tests showed an improvement in mechanical properties of specimens subjected to various forms of vibration. This should be carried out from the start of pouring until solidification is complete.

35. Silin, L. L.
THE APPLICATION OF ULTRASONICS IN WELDING AND CASTING PROCESSES. RTS 1715. Apr 1962. 62p. Order from OTS or SLA $6.60, 62-24773 (Translated from Primenenie Ultrazvuka v Svarochnykh i Liteinykh Protsessakh, Moscow, 1959)

36. Silin, L. L.
The influence of an ultrasonic field on the structure and formation of cracks in the metal of a joint during arc welding. IZVEST. AKAD. NAUK SSSR, MET. I TOPL. 3:39–43, 1960. (In Russian)

Vibration amplitude determines the degree of structural change in a metal during solidification. Exceeding a definite amplitude level changes the normal welding process and impairs the external appearance of the joint, increases the splashing of metal from the bath, and the formation of slag inclusions in the joint. The value of the upper limit is determined by the properties of the liquid metal. The formation of cracks occurs when elastic deformation in the basic metal exceeds the plasticity of the solidifying metal. In most cases, the crystalline cracks occur in regions with the greatest elastic deformation. The tendency for the metal in the joints to form cracks depends on the composition of the metal and the structure obtained during solidification. The tendency for crack formation decreases as the structure becomes finer. The results provide the basis for a method using ultrasonic waves to give a quantitative estimate of the tendency for a metal to develop hot cracks.

37. Stirring discovery improves welds.
STEEL 149:88–89, 6 Nov 1961.

Weld deposits in aluminum alloys, stainless steel and titanium are improved and the grain structure is refined when an electromagnetic field is applied around the arc. Mechanical vibration and seeding techniques are also used.

38. Teumin, I. I.
Methods and characteristics of introducing elastic vibrations into solidifying metals.
IZVEST. AKAD. NAUK SSSR, MET. i TOPL (Tekhn.) 1:24–30, 1961.

The introduction of elastic vibrations in the lower part of a solidifying billet eliminates zone solidification and vibrations can be applied from the beginning of casting. Among the disadvantages are the necessity of using a large amount of power for large billets. The use of vibrations in the top of the melt is the least effective method and can be used only in special cases. An intermediate treatment of the billet has several advantages but requires a critical temperature and pouring rate. Vibrations used at the top of a melt during continuous or semicontinuous casting are applied most efficiently.

39. Walker, J. L.
Grain refinement by vibration. JOURNAL OF METALS 13:379, May 1961.

A brief state-of-the art report. Results of theoretical and experimental work in process may provide a quantitative explanation of the mechanism by which the vibration of a melt induces nucleation. Current work is directed toward finding the effect of pressure and turbulence on nucleation kinetics.

40. Zaboleev-Zotov, V. V. and G. I. Pogodin-Alekseev
Effect of ultrasound on the formation of the structure of eutectic alloys. METALLOVEDENIE i OBRABOTKA METALLOV 1:2–6, 1958.(In Russian)

Ultrasound broke up dendrites and caused grain refinement, producing compact, spherical grains. Cooling curves showed that ultrasound reduced the cooling rate under otherwise identical conditions and the time for the eutectic transformation is a function of acoustic power. The mechanism of the action of ultrasound on crystallization is discussed.

SUBJECT INDEX